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Environmental Impact of Nuclear Power Plant (Rooppur Nuclear Power Plant) on Third World Country like Bangladesh

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ABSTRACT
Nuclear power is the use of nuclear reactions nuclear that release nuclear energy to generate heat which most frequent is then used in steam turbines to produce electricity in a nuclear power plant. Bangladesh first conceived building a nuclear power plant in 1961. Bangladesh Atomic Energy Commission was established after independence in 1973. The country currently operates a TRIGA research reactor at the Atomic Energy Research Establishment in Savar. More recently, in 2001 Bangladesh adopted a National Nuclear Power Action Plan. On 24 June 2007, Bangladesh government announced plan to build a Nuclear Power Plant to meet electricity shortage. In May 2010, Bangladesh entered into a civilian nuclear agreement with the Russian Federation. This research paper also deals about the safety aspects of this power plant & RNPP Project Timeline, Overall Safety Management including Effluent treatment and Human safety &Protection from external impacts as well.

Keywords: Nuclear Power, Atomic energy, Electric Energy, RNPP Project Timeline, Safety Management and Radio-Active Waste Management of Nuclear power plant.

1. Introduction

Nuclear energy is the abundant source of heat energy which can be transferred into many useful form of energy like Electrical energy or Electricity. The heart of nuclear energy Uranium was discovered in 1789 by Martin Klaproth, a German chemist, and named after the planet Uranus. Nuclear provides about 6% of the world's energy and 13–14% of the world's electricity.[1] U.S., France and Japan together account for about 50% in nuclear generated electricity. The IAEA (**I**nternational **A**tomic **E**nergy **A**gency) re-ported there were 439 nuclear power reactors in operation in the world. These nuclear power reactors are operating in 31 countries. The safety record of nuclear power is good when compared with many other energy technologies. Research into safety improvements is continuing. Besides this there are also some major accidents in Nu-clear Power plants. The Chernobyl disaster was a nuclear accident that occurred on 26 April 1986 at the Chernobyl Nuclear Power Plant in Ukraine (officially Ukrainian SSR), which was under the direct jurisdiction of the central Moscow's authorities.[1,5] A proposed site for the first nuclear power plant in Bangladesh, was selected in a remote village called Ruppur in Pabna district in the western zone of Bangladesh near the state of West Bengal in India. The site at Ruppur, downstream of the Hardinge Bridge over the Ganges (Padma), was thus a natural choice for a nuclear power plant. After receiving the positive response of IAEA, Bangladesh Government decided the Ruppur power plant on its own concept. At last 24th February, 2011 Bangladesh government signed a primary deal with Russia for installing a 2000 MW nuclear power plant at Ruppur in Pabna. By signing the deal, the government launched country's first **N**uclear **P**ower **P**lant project (NPP) which would be completed in 2017-18 at the cost of US$ 1.5 to 2 billion.

2. Theoretical Redaction

Ruppur Nuclear Power project conceives in 1961 to meet the deficiency of future electric shortage. A number of feasibility studies had done before the liberation war of Bangladesh. After the liberation war selected site was taken for nuclear power plant project in Ruppur, Pabna. The selected land for the plant was 103.5 ha and the land for the rehabilitated people was 12.15 ha. There were three different projects approved by National Economic Council. They were 70MW in 1963, 140MW in 1966 and 200MW in 1969. Initial negotiations started in the early 1960s with USAID for a 70 MW nuclear power Plant at Ruppur in 1963.As time passed, the reactor vendors were changed, the size of the power plant was increased and some feasibility reports were prepared, but no contract was signed. It is because the government of Pakistan was not concerned about the project. By this time in 1965 the contract for the con-

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struction of a 125 MW Pressurized Heavy Water Reactor(CANDU) in Karachi in West Pakistan, was signed with Atomic Energy of Canada Ltd. (AECL) without any feasibility study, even though there was a cabinet decision to build the first nuclear power plant in Pakistan at Ruppur.[2] Several senior engineers and the Project Manager of the Ruppur Nuclear Power Project were transferred to the Karachi Nuclear Power Plant (KANUPP), thus crippling the Ruppur project. In 1968, PAEC received a proposal from V/o Techno prom export of Moscow to supply a 400 MW **P**ressurized **W**ater **R**eactor (PWR) nuclear power plant with two turbines of 200MW each for Ruppur. At the same time a Beigial firm submitted a project proposal for a 200MW PWR plant in 1969.This offer appeared to be more attractive than the Russian one in view of the small size of the grid in the western zone of East Pakistan and some unresolved safety issues of the Russian reactor. It may be mentioned here that the proposed Russian reactor did not have any containment building, an essential safety feature designed to contain any release of radioactivity to the atmosphere in case of a nuclear accident. All the terms and conditions of the supply, construction and erection of the nuclear power plant were finalized with WENESE and the contract was due to be signed in early 1971.But after the liberation war the project was not in service due to the effect of after war financial crisis. A French consulting firm started a feasibility study in 1977 and finished it in 1978 with a conclusion that Ruppur project is suit-able for 125 MW Reactor. The contract was signed in 1979.The executive committee of national economic council gave approval of 125 MW project. But the funding source from Saudi Arabia was failed to finance the project due to some reasons. Latter on from 1987-1988 M/S Lahmeyer of Germany and M/S Motor Columbus of Switzerland conducted the latest study and unfortunately this project was also failed. After receiving the positive response of IAEA, Bangladesh Government decided the Ruppur power plant on its own concept. At last 24th February, 2011 Bangladesh government signed a primary deal with Russia for installing a 2000 MW nuclear power plant at Ruppur in Pabna.

3. Methodology

3.1 Reactor Coolant System Analysis:

The reactor coolant system removes the heat from the reactor core by coolant circulation in a closed circuit and provides heat transfer to the secondary side. The reactor coolant system comprises a reactor, a pressurizer and four circulation loops, each one comprising a steam generator, reactor coolant pump set and main coolant pipelines that provide the loop equipment-to-reactor connection.

3.2 Reactor Core and Fuel Design:

The reactor cores contain 163 fuel assemblies (FA). The FAs are intended for heat generation and its transfer from the fuel rod surface to coolant during the design service life without exceeding the permissible design limits of fuel rod damage. The FAs are 4570 mm high (nominal value). When the reactor is in the hot state the height of the power generating part of the fuel rod is 3750 mm. Each FA contains 312 fuel rods. The FA skeleton is assembled of 18 guide channels, 13 spacer grids welded to them, an instrumentation channel and a support grid. The fuel rod cladding is a zirconium alloy tube. Sintered UO_2 pellets with a 5% (4.95±0.05) maximum enrichment are stacked inside the cladding. The average linear heat rate of a fuel rod is 167.8 W/cm.[5, 13]

3.3 Nuclear Fuel Storage and Handling Systems:

The nuclear fuel storage and handling system complex& complicated system which is a set of systems, equipment and components designed for nuclear fuel storage, loading, unloading, monitoring and transfer. The complex comprises a number of systems and equipment to implement all the fuel handling procedures on the site.

3.4 Reactor Type:

This is a pressurized water reactor. Pressurized Water Reactors keep water under pressure so that it heats, but does not boil. This heated water is circulated through tubes in steam generators, allowing the water in the steam generators to turn to steam, which then turns the turbine generator. Water from the reactor and the water that is turned into steam are in separate systems and do not mix.This reactor type consists of Steam Generator, feed water supply and distribution systems, distribution perforated plate, submerged perforated plate, chemical feeder, reactor Coolant Pump, main coolant pipeline, a vertically positioned pressurized cylindrical vessel with elliptic bottoms, auxiliary systems (pneumatic valves) and Alternative Fuel like MOX (**M**ixed **Ox**ide) fuel. [3]

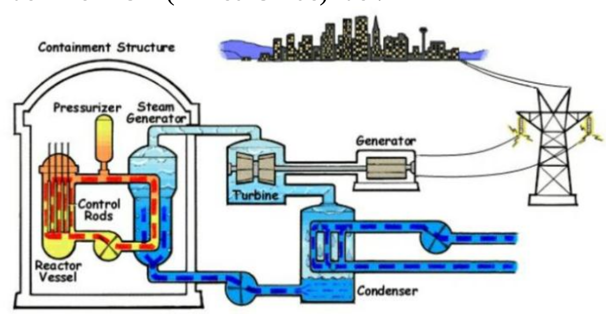

Fig 1: Nuclear power plant using pressurized water reactor

3.5 Spent Fuel (Sf) and Sf Handling Schedule:

Spent fuel is taken out of the reactor to be installed for storage in the spent fuel pond. It is located in the reactor hall inside the containment close to reactor cavity. During reactor refueling the fuel cooled in the spent fuel pond is taken to the spent fuel storage. The spent fuel storage is designed for dry storage on the NPP site in double purpose casks designed both for transport and storage. The spent fuel storage tank is designed for long-time storage of the spent fuel accumulated for 10 years of operation of two units with a possibility for the capacity of the building to be expanded in the future to keep the fuel accumulated during the Unit service life.[9]

4. Turbine-Generator Systems:

4.1 Turbine Generator:

Turbine is a single-shaft five-cylinder set and comprises a double-flow high pressure cylinder (HPC) and four double-flow low pressure cylinders (LPC). Without the generator the turbine is 52.3 m long, and with the generator it is 74.5 m long. The schematic thermal diagram of the turbine plant comprises four stages of low pressure heaters, a deaerator, and two stages of high pressure heaters. The main parameters of the turbine plant operation under nominal conditions with reactor plant thermal power 3212 MW are presented in Table 1.

Table 1: Main parameters of the turbine plant operation

Parameter	Value
Nominal pressure of steady state conditions, MPa	16.1
Nominal temp. of steady state conditions, °C	347.9
Design pressure(gauge pressure), MPa	1764
Design wall temperature, °C	350
Internal diameter, mm	3000
External diameter, mm	3330
Capacity(full volume), m^3	79
Water level of nominal power operation, m^3	55
Water level under steady state conditions, m	8.17±0.15
Working medium	Steam &water; N_2 under heatup/cooldown conditions
Quantity of TEH groups, pcs.	4
Total power of PRZ TEHs, kW	2520

4.2 Feed Water System:

Feed water system is consists of two main parts. They are: Main feed water system (continuous water supply at a rate of 300 – 6480 t/h through the main control feed water valves and at a rate of not less than 350 t/h) and Auxiliary feed water system (anticipated operational occurrences in case of a shutdown and subsequent cool down, under the conditions of loss of normal heat removal through the secondary side).

4.3 Power Supply Systems:

There two accepted electric wiring circuitry proposed in RNPP (**R**uppur **N**uclear **P**ower **P**lant) are the 500 kV switchgear "breaker-and-a-half" scheme and the 220 kV switchgear – two working bus bar systems.

5. Power Plant Safety & Waste Management:

5.1Safety Requirements & Principles:

The VVER-1200 (AES-2006) plant was designed to meet the Russian general safety requirements issued in 1997, which were consistent with the IAEA's **I**nternational **N**uclear **S**afety **G**roup (INSAG) recommendations. Thus all new VVER-1200 plants under construction already have design features that take fully into account the main "Fukushima lessons learned", including: long term cooling of reactor core without electrical power, long term decay heat removal that does not rely on primary ultimate heat sink, protection of reactor containment integrity with dedicated systems after a core meltdown accident, the inherent-safety principle, that is, the ability of the reactor to ensure safety based on natural, feedback processes and characteristics and defense in depth principle, that is, use of successive barriers preventing the release of ionizing.[4]

5.2 Provision of Fundamental Safety Functions:

Reliable provision of the three fundamental safety functions has been the leading principle in the design of VVER-1200(AES-2006) plants.

5.3 Control of Reactivity:

All VVER-1200 reactors have a unique safety features, when compared with other PWR types or older VVERs: if the control rods are inserted into the core the reactor will stay in shutdown state even at low temperature over the long term.

5.4 Decay Heat Removal:

In the VVER-1200, decay heat can be removed in three different ways Firstly, by active systems to the main ultimate heat sink or to a separate dedicated "spray pond". Secondly, by active systems to atmosphere (feed and bleed from steam generators). Finally, by passive systems to atmosphere. On the other hand, passive decay heat removal is an important advanced feature for ensuring safety of the VVER-1200.[10]

5.5 Containment of Radioactive Material:

Ensuring VVER-1200 containment integrity in the event of these circumstances is based on systems that are completely independent and separated from the systems that are intended to prevent severe reactor core damage. Containment overpressure is prevented by the **C**ontainment **P**assive **H**eat **R**emoval **S**ystem (CPHRS).[8] Accumulation of hydrogen is prevented by passive hydrogen re-combiners, with some contribution from the core catcher, which is also the main system for elimination of steam explosion, containment bottom penetration and re-criticality of the molten core.

5.6 Radioactive Waste Management:

A complex of spent fuel handling systems was realized in the RP AES-2006 and V-392M design. The in-containment spent fuel storage system is designed to cool the spent fuel taken out of the reactor in order to reduce the former's activity and residual heat to the values that are permissible at transportation. When the service life of a NPP Unit has expired and it is decommissioned, the spent fuel handling equipment is subjected to the procedures that are in preparation stage: removal of spent fuel from the NPP Unit, coolant discharge and reactor and spent fuel pond drying, coolant treatment in the dedicated water purification unit, equipment decontamination as per standard process procedure, At the stage of the Unit preparation for the observation period, equipment conservation at the standard places. [6]

6. Environmental Impacts:

6.1 Population Density:

The first and major consideration to set a RNPP is the area and density of the people. According to the international law the radius of the area of nuclear power station is 30Km.The area is divided in to three circular zone with $3.14(30)^2$=2,826Sqr Km area. According to the zone, zone-1 is reactor area, zone-2 is security area and zone-3 is for planning disaster. The area of zone-1 is a circular area of 3.14 Sq. Km. This area is only for the people who are working with reactors, others entrance is strictly prohibited. The distance of zone-2 is 5 Km away from the center and the total area of is $3.14\ (5)^2$=78.5 sq. Km. This area is prohibited for agriculture and industries and only 3 people can leave per sq. Km that is the total people of that zone will be only 200.The distance of zone-3 is 30 Km from the center.[7] This 30 Km area must be free of population. If there are more people than there will be obstacles for rescuing the people. Developed countries nuclear power stations are free of population. That is for those reactors among 30Km is free from population. For example if there is an explosion in RNPP like Three Miles Island than people leaving there must be transferred $3.14(40)^2$=5024 sq. Km area. So if 1000 people leave per Sqr Km then almost 1000000 people must be transferred from that area. It is quiet impossible. But the problem can be solved through changing some regulation. According to the international law some changes is applicable depending the situation. For example India has changed some regulation to build their nuclear powerplant.[12] The have changed the zonal area. The do this because they have the same problem of large population like Bangladesh. But there is a considerable think that as per there total country area the population is to very big. Therefore Bangladesh can their policy can be a little bit safe.

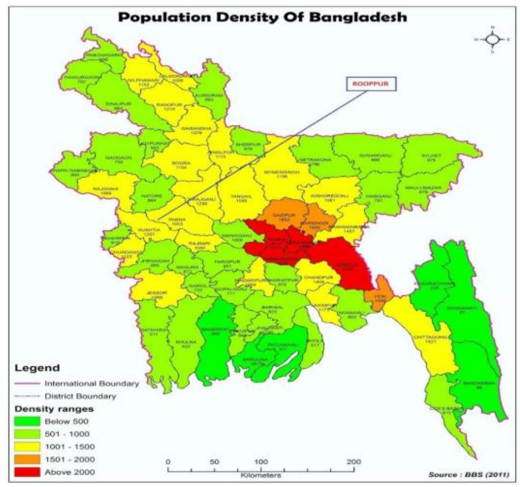

Fig 2: Population density map of Bangladesh

6.2Earthquake & Natural Disasters:

The second major problem is earthquake and natural disaster. From the experience of Fukushima Daiichi Nuclear Power plant in Japan 9.0 MW earthquake occurred at 14:46 JST on Friday, 11 March 2011 with epicenter near the island of Honshu. It resulted in maximum ground accelerations of 0.56, 0.52, 0.56 g (5.50, 5.07 and 5.48 m/s^2) at Units 2, 3 and 5 respectively, above their designed tolerances of 0.45, 0.45 and 0.46 g (4.38, 4.41 and 4.52 m/s^2), but values within the design tolerances at Units 1, 4 and 6. When the earthquake occurred, the reactors on Units 1, 2, and 3 were operating, but those on Units 4, 5, and 6 had already been shut down for periodic inspection. Units 1, 2 and 3 underwent an automatic shutdown when the earthquake struck. When the reactors shut down, the plant stopped generating electricity, stopping the normal source of power for the plant. The subsoil investigations, geotechnical, site specific seismic hazard assessment investigation, any heavy structure like RNPP with the design basis H PGA values above 0.2g-0.25g could withstand a 7.5-9.5 Mw earthquake and can damage the RNPP in future. RNPP will be located in Pabna which is situated in the South-Western Region of Bangladesh and there is no big and wide river which will affect the nuclear power plant even though there is tsunami.[15]

6.3 Nuclear Waste:

The waste from nuclear power plant in Ruppur is a major consideration. The waste from nuclear power plant will be radioactive and the wastes will be radioactive. Radioactive wastes are wastes that contain radioactive material. Around 20–30 tons of high-level wastes is produced per month per nuclear reactor. There are some 65,000 tons of nuclear waste now in temporary storage throughout the U.S., but in 2009, President Obama "halted work on a permanent repository at Yucca Mountain in Nevada, following years of controversy and legal wrangling". There are three types of waste. High–level, Mill Tailings and Low level waste. Among these high level waste is most dangerous. During fission, very harmful radiation rays are released. The most harmful of which are gamma rays. When the human body is exposed to radiation, it can cause tumors and can do extreme damage to the reproductive organs. For this reason, problems associated with radioactivity can be passed on to the victim's children as well. That is why radioactive waste produced by nuclear power plants is so toxic & dangerous. Radioactive fission products could pose a direct radiation hazard, contaminate soil and vegetation, and be ingested by humans and animals. Human exposure at high enough levels can cause both short-term illness and death, and longer-term deaths by cancer and other diseases. So it has seen that radioactive waste can cause a great herm in Bangladesh if any disaster is occur in the future nuclear power plant. But there is nothing to be worried about it.[11] Because there are new waste disposal technologies invented now a days. Bangladesh can use Experimental Breeder Reactor II.A breeder reactor is a nuclear reactor that generates more fissile material in fuel than it consumes. Breeder Reactor II is being developed by Argonne National Laboratory in the US; almost 100% of the transuranic nuclear wastes produced through neutron capture can be caused to fission. Generally, the fission products created have shorter half-lives and are not as dangerous. This reactor, dubbed EBR-II, uses liquid sodium as a coolant, which means that the internal reactor temperature is much, much hotter than that of a normal PWR reactor, which uses water as a coolant. Another advantage of EBR-II (**E**xperimental **B**reeder **R**eactor) is that its fuel is not weapons grade quality. When the transuranic wastes are separated from the other wastes in the spent fuel rods, the resultant mix of isotopes cannot be used in a bomb. Thus, the mix can be used as fuel for EBR-II without a chance of it getting stolen by a terrorist group for use in an explosive device. Breeder reactors "breed" fuel. That is, they are designed to create 239Pu from 238U through neutron capture. This "waste" can then be used as fuel.

7.Conclusion:

At present, Bangladesh is facing energy and power crisis. The natural energy resources of Bangladesh mainly gas, coal and hydro are decreasing very rapidly due to higher population growth. Gas, being the main energy resources of the country is used mainly in three categories: power generation, fertilizer production, and household. According to Patrobangla, it would not possible to supply gas to new power plant after 2011. Due to lack of reserve of gas, government is trying to generate power from coal in large scale. But depending on different type of coal mining, the amount of recoverable coal will be different. For the higher transportation cost, fuel cost and environmental pollution, the coal based power generation is not safe for long term plan.[14, 15] Also skyrocketing oil price is a major obstacle for power generation. Water head is not available through the country which can solve power shortage by Hydro power plant. Again renewable energy sources of Bangladesh like solar, windmill and traditional biomass could not be able to fulfill the huge power and energy shortage. In that situation nuclear power plant will be a good option. The advantage of nuclear power plant over other options include: absence of greenhouse gases, lower operating cost, less fuel consumption, less sensitivity to fluctuations in the fuel price, cheaper generation cost with respect to higher capacity cost. Bangladesh has gone a long way in getting ready for nuclear power. Manpower has been trained, radiation safety bill has been passed, land for the nuclear power station has been acquired, and many feasibility studies have been made. Energy policy has clearly stated the necessity for energy security and keeps all options for power production.

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